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MEMORANDUM

To: Pete Rhoads, MWD

From: J. W. Buell, Ph.D.

Date: 24 March 2000

Subject: Upstream passage around a screened diversion at Hood

The purpose of this memorandum is to present a *brief summary* of the feasibility and approaches for safely passing upstream-migrating fish around a screened "diversion" which would pass Sacramento River water into the central Delta near Hood. Two methods of delivering water have been discussed over time in the CalFed process, "passive" and "active". The "passive" approach involves excavating a conveyance from Hood to the North Fork Molelumne via Snodgrass Slough, and allowing water to flow by gravity, driven by (usually) relatively higher stage in the Sacramento. The "active" approach involves a similar conveyance, but with a low-head pumping plant to enhance water flow. These two conveyance schemes dictate different approaches for upstream fish passage. Furthermore, any upstream passage approach will need to be compatible with the downstream screening approach; it is important to view the facility as an integrated system. Maximum conveyance of 4,000 cfs is assumed. Each of these approaches has relative advantages and disadvantages. It is also possible to implement a hybrid "active + passive" system, which would operate passively during certain river stage conditions and actively during others. The hybrid system is more complex and expensive, but could realize most of the relative advantages and avoid most of the relative disadvantages.

Passive Conveyance

Two approaches to downstream screening and upstream passage of a passive conveyance are feasible, assuming a maximum 4,000 cfs conveyance; with greater capacity, one approach becomes impractical and drops out. The first approach is a "compound V" set of screens located near the head of the conveyance canal, similar to the system envisioned for the Isolated Facility alternative in the CalFed process. Downstream migrants entering the diversion canal are concentrated at the apices of the V's and shunted via fish pumps to sorters to be returned to the Sacramento River about a mile downstream (to avoid recycling fish due to tidal flow reversals under some stage conditions). Upstream migrants are concentrated to the opposite apices of the V's, each of which can be configured as a vertical slot or a vertical series of orifices. Upstream migrants could simply pass through these slots/orifices and continue upstream. The slots/orifices would occupy less than 1% of the cross-sectional area of the conveyance, so a very small percentage of downstream migrants would tend to pass through them to the Mokelumne side. Precise hydraulic control of the system could easily be achieved by means of both louvers and drop-gates on the *back* (downstream) sides

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of the screens. The system could be closed, if desired, during tidally-driven flow reversals which could occur under some river stage and tidal asynchrony conditions. This approach would pass upstream-migrating salmon, steelhead, splittail, striped bass, American shad and sturgeon with little or no significant delay; minimal fall-back problems are anticipated, but some would occur. Errant Mokelumne salmon could fall back and be returned to the back of the screen array to exercise voluntary behavior. This approach would not pass upstream-migrating delta smelt. Water velocities necessary to keep fine sediments in suspension (~2 fps) would present an impossible velocity barrier for this species. Mitigation by developing local spawning habitat would be necessary (feasible). Operational constraints during the (long) delta smelt migration season may help significantly.

The second approach to downstream screening and upstream migrant passage could employ a series of flat plate screens oriented parallel to the Sacramento River bank. These would need to be separated by some distance to keep exposure time of downstream migrants within acceptable limits. No salvage facilities would be required with this arrangement; downstream migrants would simply continue moving downstream past the screen. However, this system could not be operated under certain tidal conditions common at low river stage (when the conveyance is most needed) due to inadequate sweeping velocities. The overall design capacity of 4,000 cfs pushes the limit for this approach; any greater conveyance would foreclose this approach, and planning for the future should take this into account. Hydraulic conditions on the downstream side of the screens could be readily controlled to concentrate upstream migrants to the upstream end of the screen plate to a relatively small bypass canal, which would continue about 1/4 mi or more upstream. At this point the canal would have to extend into the river some distance offshore and daylight in the river, protected by pilings. This would be necessary to avoid entraining any shoreline-oriented and shallows-oriented downstream migrants. Accommodating variable river stage could be engineered into the terminus (feasible). This approach would pass upstream-migrating salmon, steelhead and American shad with little or no significant delay. Modest delays of striped bass and splittail may occur due to the canal approach; data for splittail entering a flume or canal are essentially non-existent. Sturgeon delays and rejection might be significant, but a trap-and-haul system could be retrofitted into the system if a problem was identified. Fall-back problems would not occur with this approach, since the screen system would not incorporate a salvage/bypass for downstream migrants. Errant Mokelumne River salmon could not "change their minds" and return. This approach would not pass upstream-migrating delta smelt for the same reason as the first approach; mitigation would be necessary.

Advantages of the passive conveyance approach include lower cost and relative simplicity of operation. Disadvantages include lack of ability to "boost" conveyance when river stage differential is insufficient to drive the desired amount of water into the central delta (typically at low river stage).

Active Conveyance

This conveyance approach would involve a low-head pumping station which would boost water from the Sacramento River about 4 ft above nominal river stage, resulting in much greater control over

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water flow into the central delta. This approach would require two sets of screens, one on the upstream side of the pumps for downstream migrants, and another on the downstream side of the pumps for upstream migrants. The two configurations for the downstream migrant screens, "compound V" and flat shoreline plate, would still be feasible, the first with salvage facilities and the second without. Passage of upstream migrants with active conveyance becomes more complicated, but could be achieved for most species. Fish must move from a higher water surface elevation to a lower one while swimming upstream. Several approaches are available, all with relative advantages and disadvantages; a hybrid system may be required. Salmon and steelhead, and to a limited extent American shad, can be concentrated into a canal (see above) and encouraged to pass over a "false weir", a flume section terminus with an upwelling diffuser floor grate. Once over the end plate, fish slide to a lower elevation and arrive in a canal much like that for the second passive conveyance configuration described above. No data are available on reactions of splittail to this approach, but it is likely that at least some would negotiate the route. Striped bass may experience delay or reject the false weir. Some sturgeon may negotiate the false weir, but delays are to be expected. For these species, either a lock or a trap-and-haul system may be required. An adaptive approach would be to develop a prototype facility at the existing Delta Cross-Channel and test various configurations. If the false weir appears satisfactory for these species, the full sized 4,000 cfs facility should be designed so that a lock or trap-and-haul system could be retrofitted at a later date if necessary. Due to the sediment problem described above, delta smelt cannot be passed upstream; mitigation and operational flexibility must be relied upon for this species. Darryl Hayes is preparing a list of investigations which could be performed at a prototype facility (DCC) to facilitate selection of the optimum configuration.

Advantages of the active conveyance approach include much better control over the water diverted into the central delta. Disadvantages include significantly higher cost and more complex operation.

Hybrid Active / Passive Conveyance

This conveyance approach could incorporate elements of both active and passive conveyance systems and could realize the relative advantages of both systems while avoiding most of the relative liabilities. A hybrid system could incorporate either flat plate or "compound V" fish screens for downstream migrants, as described above. On the downstream side of these screens, the channel would be split, with one arm leading to a low-head pumping facility and the other bypassing this facility. These two channels would then re-converge. During operation, water would be shunted to one of the channel arms with the other arm isolated by flat gates at both ends, angled in the canal in a manner which would produce smooth flow lines no matter which approach is in operation.

The primary advantage of this hybrid approach is that it could be operated passively when Sacramento River stage is sufficient to drive the desired amount of water to the Mokelumne system. Typically, this condition exists during the migration season for most or all of the species capable of being passed upstream by any means. The need for the active mode of operation is typically

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during low Sacramento River stage, outside the migration window for species of interest. Thus, passive operation would dominate in periods when this mode is most appropriate for upstream passage because of its greater efficiency for passing more migrating species. The primary disadvantage of the hybrid approach is its significantly greater cost than either of the other two approaches.

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